METAWEARRG

PRODUCT

SPECIFICATION v1.0

V1.0 © Mbientlab Inc.

MetaWear RG / RPro

Wearable and connected devices product solution

Product Specification v1.0

Key Features

- Nordic Semiconductor nRF51822 BLE SoC
  - 2.4 GHz transceiver
  - ARM® Cortex™-M0 32 bit processor
  - 256 kB flash program memory
  - 16 kB RAM
  - 8/9/10 bit ADC
- Bosch® BMI160 6-Axis Accelerometer/Gyroscope
  - ±2g/±4g/±8g/±16g selectable scale
  - 125/250/500/1000/2000 degrees/sec
  - 16-bit resolution
  - Data rates from 0.78Hz to 3200 Hz
  - Embedded event detection processor
  - Industry Leading 900uA active current gyro
- Bosch® BMP280 Digital Pressure Sensor
  - 30 to 110 kPa range
  - 0.16 Pa resolution
- Lite-On® LTR-329ALS-01 Ambient Light Sensor
  - 0.01 to 64k lux range
- Lithium Ion/Polymer battery charger
- Ultra-Bright RGB LED
- Miniature push-button switch
- High current driver for external vibration motor
- Accurate Thermistor Temperature Sensor
- Micro-USB rechargeable
- I/O Expansion
  - Digital I^2C Bus
  - 4 Analog/Digital Pins
  - 4 Digital Pins
- Tiny 26mm x 17mm x 2.5mm form factor
- FCC, Telec, CE, IC C-Tick certification

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1 Introduction

MetaWear is a complete development and production platform for wearable and connected device applications. It features the ultra-low power nRF51822 SoC, providing energy efficient smartphone communication and central processing. MetaWear integrates this radio with high value sensors and a rechargeable battery architecture into a miniature form factor. All circuits have been designed from the ground up with energy efficiency in mind.

2 Product Overview

2.1 Block Diagram

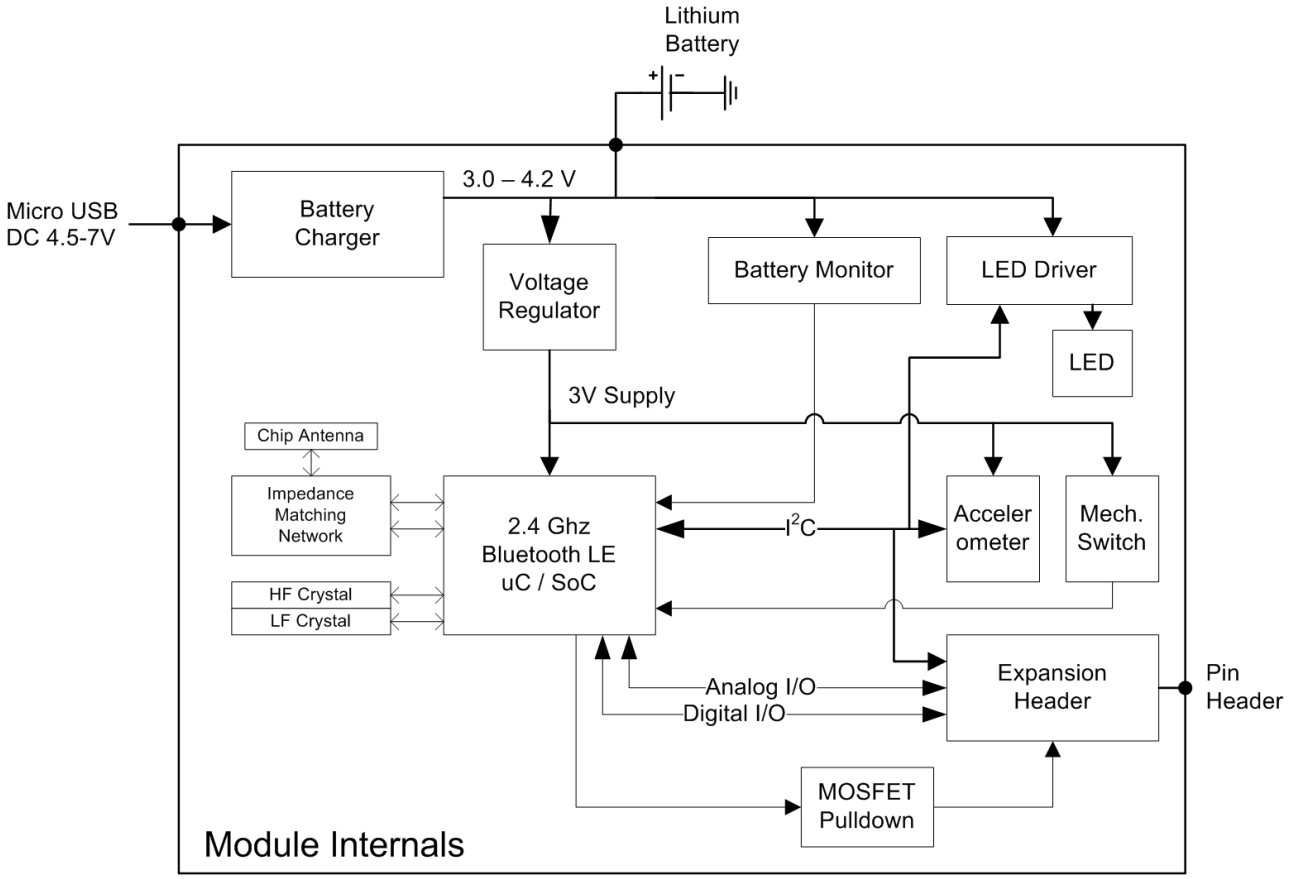


Figure 1 *Block Diagram*

2.2 Pin Assignments

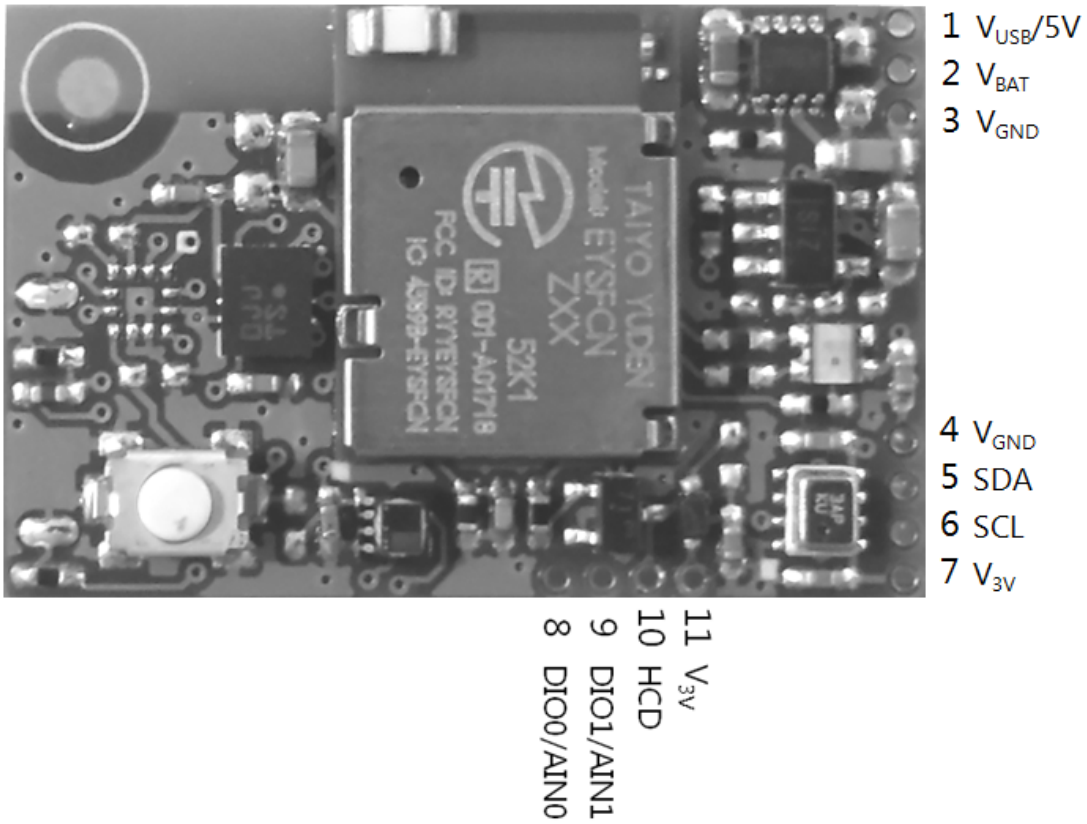
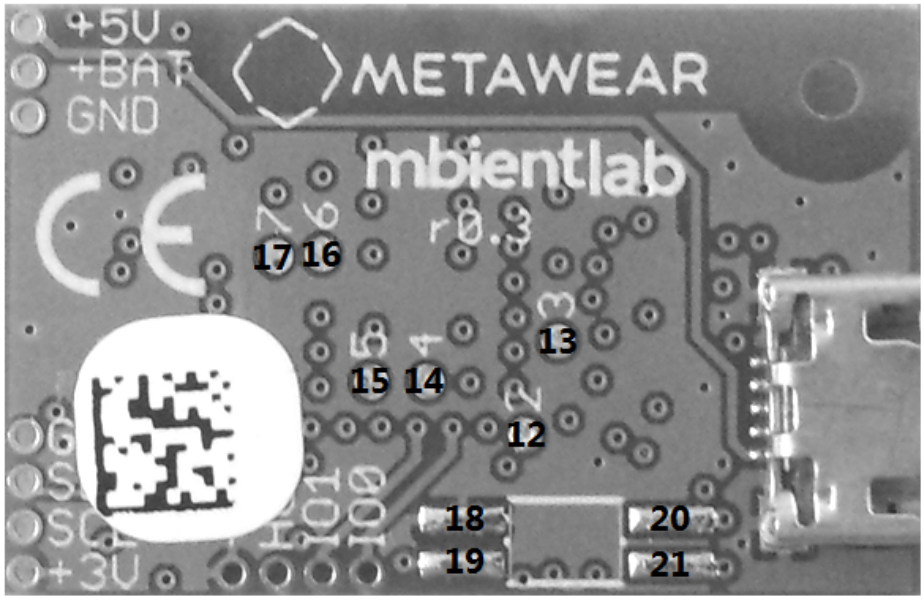


Figure 2 *Front Pin Assignments*



12 DIO2/AIN2
13 DIO3/AIN3
14 DIO4
15 DIO5
16 DIO6
17 DIO7

18 V_{3V}
19 V_{GND}
20 SWDIO
21 SWDCLK

Figure 3 *Back Pin Assignments*

2.3 Pin Functions

Pin	Pin Name	Function	Description
Power Supply			
1	V_{USB}	Power	Positive supply alternative to micro USB port.
2	V_{BAT}	Power	Positive battery connection.
3	V_{GND}	Power	Ground connection intended for battery.
Digital Peripheral Bus			
4	V_{GND}	Power	Supplementary ground for peripheral expansion.
5	SDA	Digital I/O	I^2C serial data.
6	SCL	Digital I/O	I^2C serial clock.
7	V_{3V}	Power	Regulated 3V output for peripheral expansion.
Analog / High Current Driver Bus			
8	DIO0 AIN0	Digital I/O Analog I/O	General purpose I/O and analog input.
9	DIO1 AIN1	Digital I/O Analog I/O	General purpose I/O and analog input.
10	HCD	High Current Driver	Switch for sinking high current peripherals.
11	V_{3V}	Power	Regulated 3V output for high current peripheral.
Surface Mount Extra Breakout			
12	DIO2 AIN2	Digital I/O Analog I/O	General purpose I/O and analog input.
13	DIO3 AIN3	Digital I/O Analog I/O	General purpose I/O and analog input.
14	DIO4	Digital I/O	General purpose I/O.
15	DIO5	Digital I/O	General purpose I/O.
16	DIO6	Digital I/O	General purpose I/O.
17	DIO7	Digital I/O	General purpose I/O.
SWD Debug Header			
18	V_{3V}	Power	System supply for debugger.
19	V_{GND}	Power	System ground for debugger.
20	SWDIO/nRESET	Debug	SWD debugger I/O line and system reset.
21	SWDCLK	Debug	SWD debugger clock line.

Table 1 *Pin Functions*

2.4 Module to SoC Pin Mapping

Module Pin	nF51822 Pin	Function	Description
GPIO			
DIO0/AIN0	P0.04	GPIO	General purpose I/O and analog input.
DIO1/AIN1	P0.03	GPIO	General purpose I/O and analog input.
DIO2/AIN2	P0.06	GPIO	General purpose I/O and analog input.
DIO3/AIN3	P0.01	GPIO	General purpose I/O and analog input.
DIO4	P0.13	GPIO	General purpose I/O.
DIO5	P0.15	GPIO	General purpose I/O.
DIO6	P0.24	GPIO	General purpose I/O.
DIO7	P0.23	GPIO	General purpose I/O.
High Current/Haptic Driver			
HCD	P0.16	Haptic	Open Drain MOSFET Pull-down.
I2C			
SDA	P0.18	Serial Bus	I^2C serial data.
SCL	P0.20	Serial Bus	I^2C serial clock.
Internal Module Pins			
	P0.12	Switch	Micro Push Button. Active Low.
	P0.05	Battery Voltage Monitor	Analog voltage at V_{BAT}*(2.2/12.2)
	P0.08	Thermistor En	Active High Enable for Thermistor
	P0.02	Themistor Voltage	Voltage output from Thermistor Voltage Divider
	P0.30	Acc/Gyro Interrupt	INT1 Pin of BMI160.
	P0.09	Acc/Gyro Interrupt	INT2 Pin of BMI160.
	P0.00	Acc/Gyro SCK	SCK Pin of BMI160.
	P0.07	Acc/Gyro MISO	MISO Pin of BMI160.
	P0.11	Acc/Gyro MOSI	MOSI Pin of BMI160.
	P0.10	Acc/Gyro nCS	nCS Pin of BMI160.
	P0.19	LED Red nEn	Current Sink for Red LED Channel.
	P0.21	LED Green nEn	Current Sink for Green LED Channel.
	P0.17	LED Blue nEn	Current Sink for Blue LED Channel.

Table 2 *Module Pin Mapping*

2.5 High Current/Haptic Drive Circuit

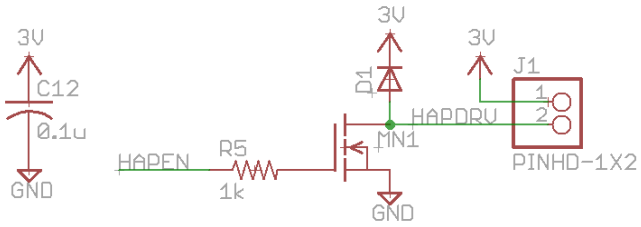


Figure 4 *Haptic Driver Circuit*

The haptic drive circuit features a logic level gate drive N-Channel MOSFET, and a flyback diode to 3V for switching inductive loads.

2.6 Battery Charging and Voltage Monitor

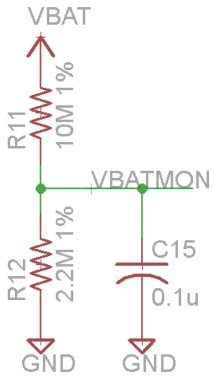


Figure 5 *Battery Voltage Monitor*

The MetaWear battery charge level is monitored via a voltage divider on the battery. Charging is managed entirely by a dedicated CC/CV charge controller chip, requiring no direct action from the main system controller.

2.7 Barometric Pressure Sensor

The Barometric Pressure Sensor BMP280 is attached to the shared I^2C bus at slave address 0x77.

2.8 Accelerometer / Gyroscope Sensor

The 6-axis accelerometer and gyroscope sensor BMI160 is attached via the SPI bus, with pin numbers detailed in the module to SoC mapping table.

2.9 Thermistor Temperature Circuit

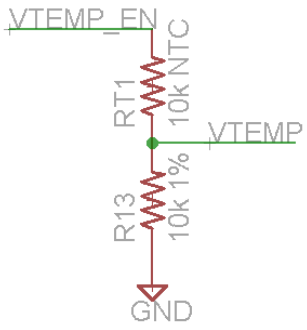


Figure 6 *Thermistor Temperature Circuit*

The thermistor circuit features a voltage divider and active high enable for power saving. Details on the sensor characteristics can be found in the data sheet for part number NCP15XH103F03RC.

2.10 RGB LED Circuit

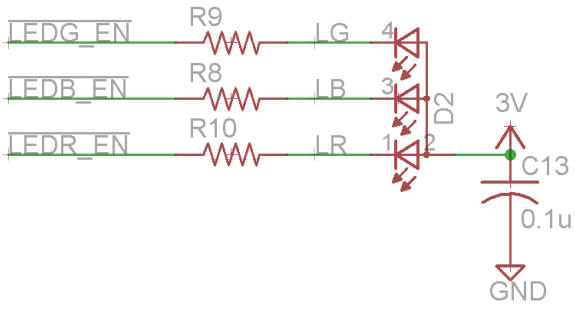


Figure 7 *RGB LED Circuit*

The RGB LED channels are driven by an active low PWM signal from the SoC. The resistance values have been chosen to approximately match intensity at 100 percent duty cycle. The high current bit should be set on the GPIOs to sink up to 5mA.

2.11 Ambient Light Sensor

The Ambient Light Sensor LTR-329ALS-01 is attached to the shared I^2C bus at slave address 0x29.

2.12 32Mhz High Frequency Crystal

If the MetaWear firmware is erased for native development, the SoC needs to be configured for use with the on board 32 MHz crystal. To do this you must write the value 0xFFFFFF00 to the UICR (User Information Configuration Register) at address 0x10001008. Please note that the UICR is erased whenever you download a SoftDevice.

The UICR can be written by using the debug tools:

nrfjprog.exe --snr <your_jlink_debugger_serial_number> --memwr 0x10001008 --val 0xFFFFFF00

Or the following code can be added to the SystemInit function in the system_nRF51.c file, right before launching the TASK_HFCLKSTART task:

```
if (*(uint32_t *)0x10001008 == 0xFFFFFFFF)
{
  NRF_NVMC->CONFIG = NVMC_CONFIG_WEN_Wen << NVMC_CONFIG_WEN_Pos;
  while (NRF_NVMC->READY == NVMC_READY_READY_Busy){}
  *(uint32_t *)0x10001008 = 0xFFFFFF00;
  NRF_NVMC->CONFIG = NVMC_CONFIG_WEN_Ren << NVMC_CONFIG_WEN_Pos;
  while (NRF_NVMC->READY == NVMC_READY_READY_Busy){}
  NVIC_SystemReset();
  while (true){}
}
```

4 Absolute Maximum Ratings

Spec	Description	Min.	Typ.	Max.	Units
V_{USB}	USB charging voltage.	-0.3		+8.0	V
V_{BAT}	Lithium battery voltage.	-0.3		+6.0	V
V_{GND}	Ground voltage			0	V
V_{IO}	I/O Pin Voltage	-0.3		+3.3	V
T_{MAX}	Storage Temperature	-40		125	°C

Table 3 *Absolute Maximum Ratings*

5 Operating Conditions

Spec	Description	Min.	Typ.	Max.	Units
V_{USB}	USB charging voltage.	4.0	5.0	7.5	V
V_{BAT}	Lithium battery voltage.	3.0	3.7	4.2	V
T_A	Operating temperature.	-25	25	75	°C
I_{IDLE}	Idle current consumption.		10	20	uA

Table 4 *Operating Conditions*

6 Electrical Specifications

6.1 General Purpose I/O (GPIO) Specifications

Spec	Description	Min.	Typ.	Max.	Units
V_{IH}	Input high voltage.	2.1		3.0	V
V_{IL}	Input low voltage.	0		0.9	V
V_{OH}	Output high voltage.	2.7		3.0	V
V_{OL}	Output low voltage.	0		0.3	V
R_{PU}	Pull-up resistance.	11	13	16	kΩ
R_{PD}	Pull-down resistance.	11	13	16	kΩ

Table 5 *General Purpose I/O (GPIO) Specifications*

6.2 Crystal Oscillator Specifications

Spec	Description	Min.	Typ.	Max.	Units
$f_{HF,NOM}$	High frequency crystal frequency		32		MHz
$f_{HF,TOL}$	High frequency crystal tolerance		±40		ppm
$f_{LF,NOM}$	Low frequency crystal frequency		32.768		kHz
$f_{HF,TOL}$	Low frequency crystal tolerance		±50		ppm

Table 6 *Crystal Oscillator Specifications*

6.3 ADC (ADC) Specifications

Spec	Description	Min.	Typ.	Max.	Units
DNL_{10b}	Differential non-linearity (10 bit mode).		<1		LSB
INL_{10b}	Integral non-linearity (10 bit mode).		2		LSB
V_{OS}	Offset error.	-2		+2	%
V_{REF_INT}	Internal reference voltage.	-1.5	1.20 V	+1.5	%
TC_{REF_INT}	Internal reference voltage drift.	-200		+200	ppm/°C
t_{ADC10b}	Sample conversion time (10 bit mode).		68		µs
t_{ADC9b}	Sample conversion time (9 bit mode).		36		µs
t_{ADC8b}	Sample conversion time (8 bit mode).		20		µs

Table 7 *ADC Specifications*

6.4 Temperature Sensor (TEMP) Specifications

Spec	Description	Min.	Typ.	Max.	Units
T_{RANGE}	Temperature sensor range.	-25		75	°C
T_{ACC}	Temperature sensor accuracy.	-4		+4	°C
T_{RES}	Temperature sensor resolution.		0.25		°C
T_{THM_RANGE}	Thermistor sensor range.	-25		75	°C
T_{THM_ACC}	Thermistor sensor accuracy.	-1		+1	°C
T_{THM_RES}	Thermistor sensor resolution.		0.125		°C

Table 8 *Temperature Sensor (TEMP) Specifications*

6.5 Battery Charger (BC) Specifications

Spec	Description	Min.	Typ.	Max.	Units
$I_{BC,OP}$	Operating current (V_{USB} powered).		0.5	1	mA
$I_{BC,LEAKAGE}$	Reverse leakage (V_{USB} disconnected).		0.4	2	µA
$V_{BC,EOC}$	End of charge voltage.	4.158	4.20	4.242	V
$V_{BC,PRECON}$	Preconditioning voltage threshold.	2.85	3.0	3.15	V
$V_{BC,RCH}$	Recharge voltage threshold.		$V_{BC,EOC}$ – 0.1		V
$I_{BC,CHNOM}$	Nominal charge current.	81	90	99	mA
$I_{BC,PCH}$	Preconditioning charge current.		9		mA
$I_{BC,TERM}$	Charge termination threshold current.		9		mA

Table 9 *Battery Charger (BC) Specifications*

6.6 High Current Driver (HCD) Specifications

Spec	Description	Min.	Typ.	Max.	Units
$I_{ON,SS25}$	Steady state on current at 25°C.			310	mA
$I_{ON,SS85}$	Steady state on current at 85°C.			220	mA
$P_{ON,SS}$	Steady state power dissipation.			280	mW
$I_{ON,PULSE}$	Pulsed current for 10 µs.			1.4	A
R_{ON}	On state resistance.		2	5	Ω
$I_{OFF,LEAK}$	Off state leakage.			1	nA
V_{CLAMP}	Clamping diode voltage threshold.		3.3		V

Table 10 *High Current Driver (HCD) Specifications*

6.7 System Voltage Regulator (VREG) Specifications

Spec	Description	Min.	Typ.	Max.	Units
V_{OUT}	Regulated output voltage.	2.93	3	3.07	V
	Line regulation.	-1		+1	%
	Load regulation.	-2		+2	%
V_{DO}	Dropout voltage.			250	mV
I_{CL}	Output current limit.	150	230	400	mA
$I_{GND,IDLE}$	System idle ground current.		1	1.3	uA

Table 11 *System Voltage Regulator (VREG) Specifications*

6.8 Accelerometer (ACCEL) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	±2		±16	g
	Resolution.	2048		16384	counts/g
f_{DATA}	Data sample frequency.	0.78		1600	Hz
$I_{12.5}$	Low data rate current (3.125 Hz).		5		uA
I_{100}	Mid data rate current (100 Hz).		24		uA
I_{100}	High data rate current (1600 Hz).		180	300	uA
$I_{STANDBY}$	Standby current.		3	10	uA

Table 12 *Accelerometer (ACCEL) Specifications*

6.9 Gyro (GYRO) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	±125		±2000	°/s
	Resolution.	16		262	counts/°
f_{DATA}	Data sample frequency.	25		3200	Hz
I_{GYRO}	Gyro active current. All Data Rates.		850	900	uA
$I_{STANDBY}$	Standby current. Included in Accel Standby Current.				

Table 13 *Gyro (GYRO) Specifications*

6.10 Pressure (BAROMETER) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	30		110	kPa
	Resolution.		0.16		Pa
f_{DATA}	Data sample frequency.			157	Hz
I_{PEAK}	Active current. Data rate and oversampling sensitive.	0.14		650	uA
$I_{STANDBY}$	Standby current.		0.1	0.3	uA

Table 14 *Pressure (Barometer) Specifications*

6.11 LED (LED) Specifications

Spec	Description	Min.	Typ.	Max.	Units
I_{RGB}	Drive current per channel.	2	4	5	mA
λ_{RPEAK}	Red peak wavelength.		624		nm
λ_{GPEAK}	Green peak wavelength.		525		nm
λ_{BPEAK}	Blue peak wavelength.		470		nm
I_{vR}	Red luminous intensity.	45	180		mcd
I_{vG}	Green luminous intensity.	112	450		mcd
I_{vB}	Blue luminous intensity.	28	180		mcd
	Viewing Angle		120		°

Table 15 *LED (LED) Specifications*

6.12 Ambient Light (ALS) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	0.01		64k	lux
	Resolution.		16		bit
f_{DATA}	Data sample frequency.	0.5		20	Hz
I_{PEAK}	Active current. Data rate and oversampling sensitive.			220	uA
$I_{STANDBY}$	Standby current.			5	uA

Table 16 *Ambient Light (ALS) Specifications*

7 Mechanical Specifications

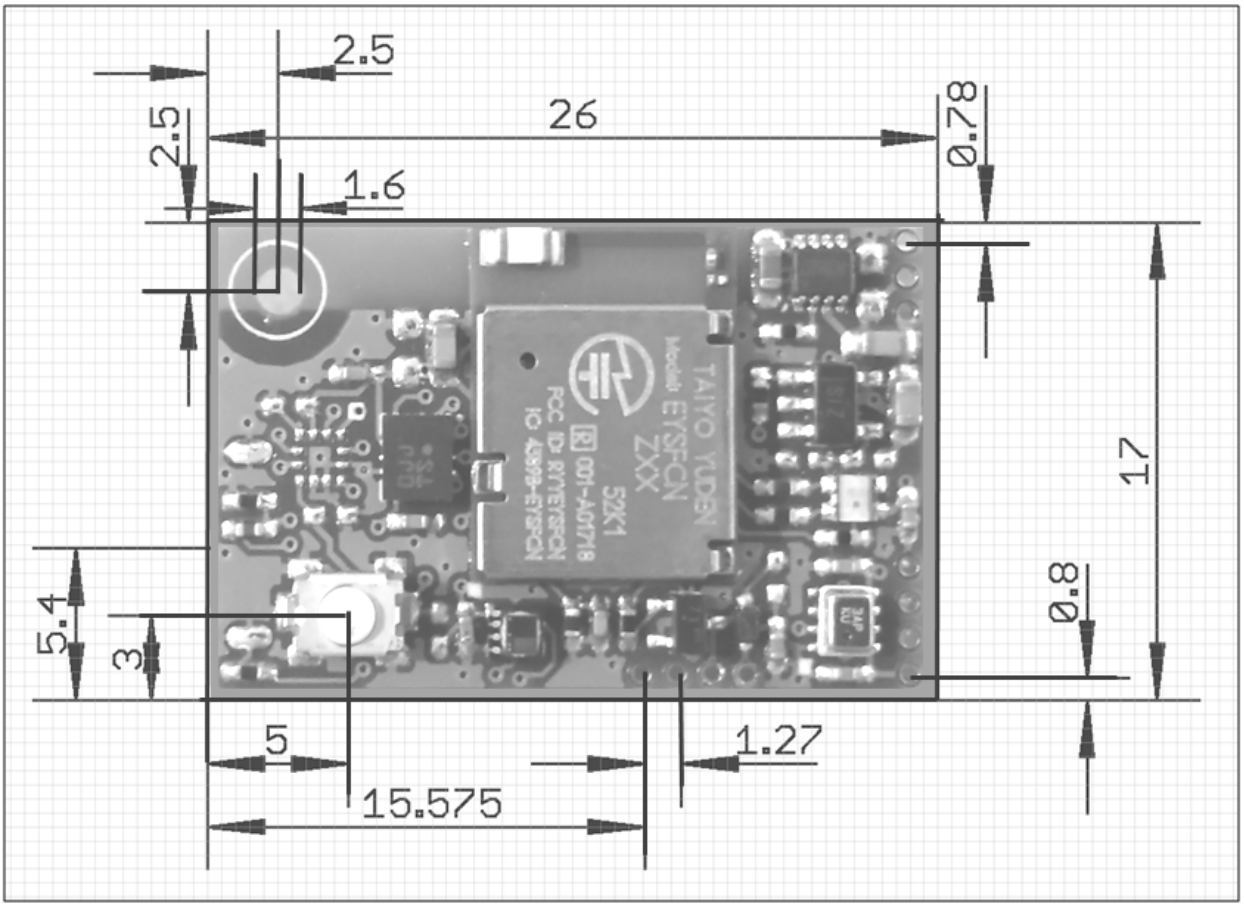


Figure 8 *Module dimensions in mm*

8 Typical Application Circuit

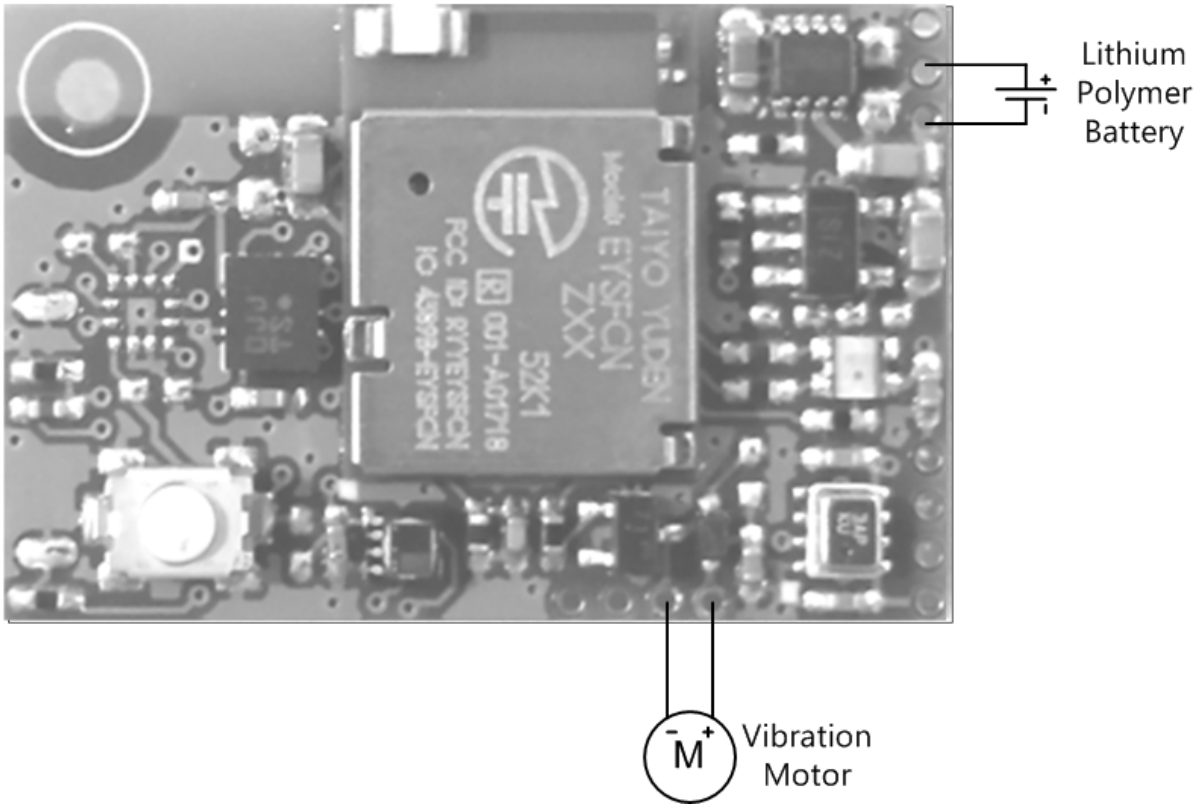


Figure 9 *Typical Application Circuit*

9 Revision History

Date	Version	Change Description
August 17, 2015	0.8	Added Details of MetaWear RG/Pro Models. Updated Module to SoC Pin Mapping.
November 11, 2014	0.7	Added MetaWear Module to SoC Pin Mapping. Added description of circuits necessary for firmware development.
July 21, 2014	0.6	Added Regulatory Statements Section Added Block Diagram. Added Back Side Pin Assignment Diagram.
June 2, 2014	0.5	Initial Draft

Table 17 *Revision History*

10 Regulatory Information for MetaWear RG and RPro

10.1 Taiyo Yuden Radio Module Approval

The MetaWear RG and RPRO use the Taiyo Yuden module, part number EYSFCNZXX. The module is Bluetooth qualified, Telec (Japan), FCC, and IC (Canada) certified.

- You can find the data sheet here: http://www.yuden.co.jp/wireless_module/document/overview/TY_BLE_EYSFCNZXX_Overview_V1.0_20131225.pdf
- Bluetooth Listing: http://www.bluetooth.com/Pages/Product-Listing-Detail.aspx?ProductID=9435
- IC: https://industrycanada.co/number.php?ic=4389B-EYSFCN&id=171601
- FCC: https://fccid.io/RYYEYSFCN

10.2 CE Conformance

The MetaWear RG and RPro boards are conformant to relevant CE specifications.

- Details: https://mbientlab.com/docs/MetaWearDeclarationOfConformity.pdf

10.3 FCC Labeling Requirements

If the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: “Contains Transmitter Module FCC ID: RYY-EYSFCN” or “Contains FCC ID: RYY-EYSFCN”. Any similar wording that expresses the same meaning may be used.

10.4 IC Labeling Requirements

Labeling requirements for Industry Canada are similar to those required by the FCC. A clearly visible label on the outside of a non-removable part of the final product must include the following text: "Contains IC: 4389B-EYSFCN".

Les exigences d'étiquetage pour l'Industrie Canada sont semblables à ceux exigés par la FCC. Une étiquette bien visible à l'extérieur d'une partie non amovible du produit doit inclure le texte suivant: "Contains IC: 4389B-EYSFCN".